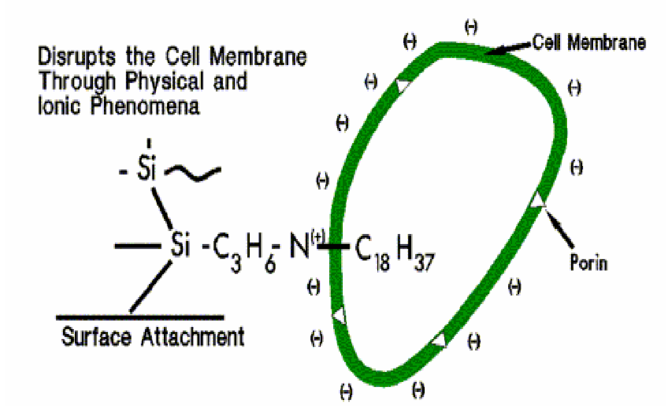
Chemistry Review - Microbe Guard's EPA Registered Antimicrobial's

This document is a review of Microbe Guard's antimicrobial chemistry, 3-trimethoxysilylpropyldimethyloctadecyl ammonium chloride (SiQuat)



SiQuat is an organofunctional silane. These chemicals are often referred to as coupling agents. Chemicals in this class of compounds are used in a wide variety of end uses where their reactivity provides coupling or adhesive characteristics. This includes adhesives and sealants used to seal glass sheets in window-walls of buildings and the adhesives used to bind the heat shield plates on the space shuttle. These uses demand the versatility, strength, and durability to severe environmental conditions that these chemicals can provide.

Silanes have been well studied and their associative and bonding capacities to themselves and to surfaces have been elucidated by many researchers. Fundamental work by Clark and Plueddemann with fiberglass suggests that silane coupling agents form covalent bonds to both the glass surface and the resin. Cited to support this theory is the similarity in chemical structure between the glass surface and the silicone functional moiety of the coupling agent, the increased laminate strengths obtained when silane coupling agents are used, and the reported copolymerization of coupling agents with reactive olefins in bulk systems[1.] Numerous other theories have been proposed to explain the interactions at the glass-coupling agent interface such as hydrogen bonding[2], Van der Walls forces[3], and water-coupling agent encystment of the glass fibers[4]. Clear experimental evidence supporting the covalent chemical bonding theory of glass - silane coupling agent - resin interactions and the uniform nature of such interactions were presented by Johannson et. al.[5] More complete reviews of the theories on the function of coupling agents have been complied by Johannson[6], Erickson[7], Plueddemann[8], and Leyden[9]. The above cited works support clearly that silane coupling agents can covalently react with receptive surfaces.

In the mid-1960's, researchers discovered that antimicrobial organofunctional silanes could be chemically bound to receptive substrates by what were believed to be Si-O linkages. The method was described as orienting the organofunctional silane in such a way that hydrolyzable groups on the silicon atom were hydrolyzed to silanols and the silanols formed chemical bonds with each other and the substrate. The resultant surface modification, when an antimicrobial moiety such as a quaternary nitrogen was included, provided for the antimicrobial to be oriented away from the surface[10].

The attachment of this chemical to surfaces appears to involve two processes. First and most important is a very rapid process which coats the substrate with the cationic species one molecule deep. This is an ion exchange process by which the cation of the silane quaternary ammonium compound replaces protons from water on the surface. It has long been known that most surfaces in contact with water generate negative electrical charges at the interface between water and the surface. This mechanism is further supported by data generated with a radioactive silane quaternary ammonium compound. During the treatment, depletion of the radioactivity from solution was almost immediate by an amount corresponding to that sufficient to cover the surface one layer deep, even on surfaces which contain no functionality. Similar results are published for many organic quaternary ammonium compounds. The second process is unique to materials such as silane quaternary ammonium compounds which have silicon functionality enabling them to polymerize, after they have coated the surface, to become almost unremovable, even on surfaces with which they cannot react. Covalent bonding to the surface will also occur and it is also possible to have intermolecular polymerization[11]

Works of Abbott, Isquith, Roth, and Walters, [12], [13], [14], [15] further elaborate the antimicrobial utility of surfaces modified with silane quaternary ammonium compounds. The specific utility of 3-trimethoxysilyl propyldimethyloctadecyl ammonium chloride AEGIS Antimicrobial, formerly SYLGARD Antimicrobial Agent based on Dow Corning 5700 Antimicrobial Agent) was described in their work and subsequent works of Gettings and Triplett[16], Speir and Malek[17], Hayes and White[18], McGee, Malek, and White[19], and White and Olderman[20].

As indicated above, the ability of silane quaternary ammonium compounds to bond and/or associate with receptive surfaces and to homopolymerize under label described conditions has been clearly demonstrated. Such bonding, where hydrolysis (drying) occurs, allows for total bonding (polymerization) of any available monomer. The oligomers formed will have infinite molecular weights limited only by the amount of monomer available. In the most restrictive of reaction systems (four monomers), the molecular weight of the silanol linked polymer will exceed 1500 MW. In on-site use, the concentration of the application strength material is between 1 .5% and 2.5%. This level exceeds by far the most restrictive system described above. Under drying conditions the amount of monomer available for hydrolysis into the reacted polymer form of this chemistry is very large. The utility of these surfaces in modifying the life processes of microbial cells has also been shown.

These descriptions of the basic and tested reaction kinetics of this molecule clearly define the polymeric nature of any dislodgeable residue. The impact of these facts on the exposure model used by EPA personnel to predict acute and chronic exposure should conclude to you of Microbe Guard’s safe and effective use over a broad spectrum of applications.